A perturbed physics ensemble climate modeling study for defining satellite measurement requirements of energy and water cycle

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Motivation

1. Uncertainty of climate sensitivity

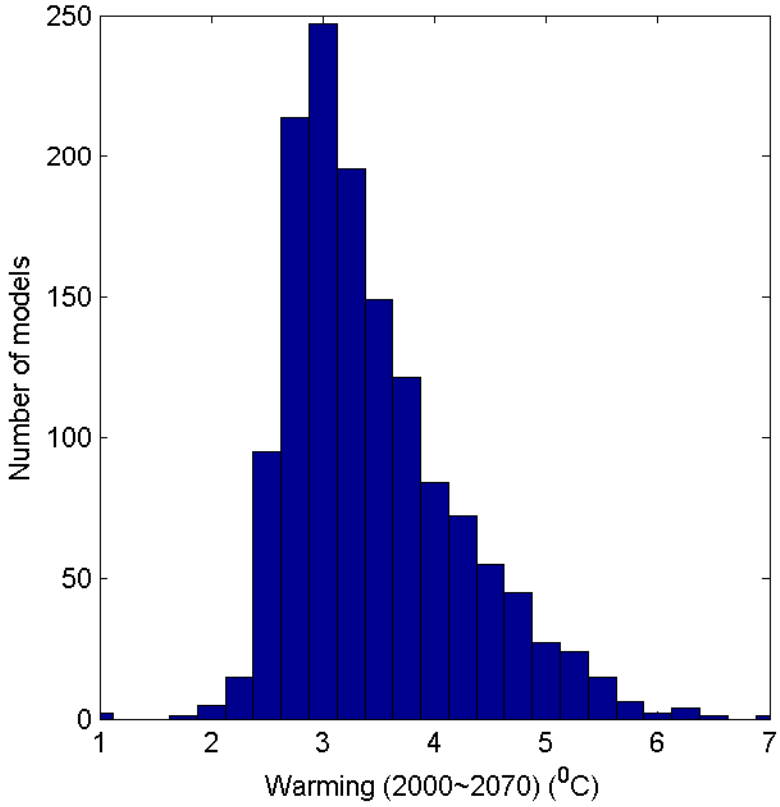
→ endless debate

→ inaction or

ill-informed policy

2. Reduction of the uncertainty:

→ metric for NASA missions



Basic Concept

Assumption:

Uncertainty in climate sensitivity

=

f (uncertainties in parameters that are observable from satellite)

Objective of this study: answering the questions

1. How good is this assumption
2. Can it help NASA define future observation requirements?

Uncertainty in climate sensitivity

=

f (uncertainties in parameters that are observable from satellite)

How to figure out the link: Using outputs from perturbed physics ensemble models

- Model outputs from climateprediction.net
- Models: HadCM3 (coupled atmosphere-ocean GCM); perturbed physics (various parameters, mostly associated with cloud parameterizations)
- About 1500 model outputs are used in this study
- Model outputs of 1920-2080 with A1B CO2

Uncertainty in climate sensitivity

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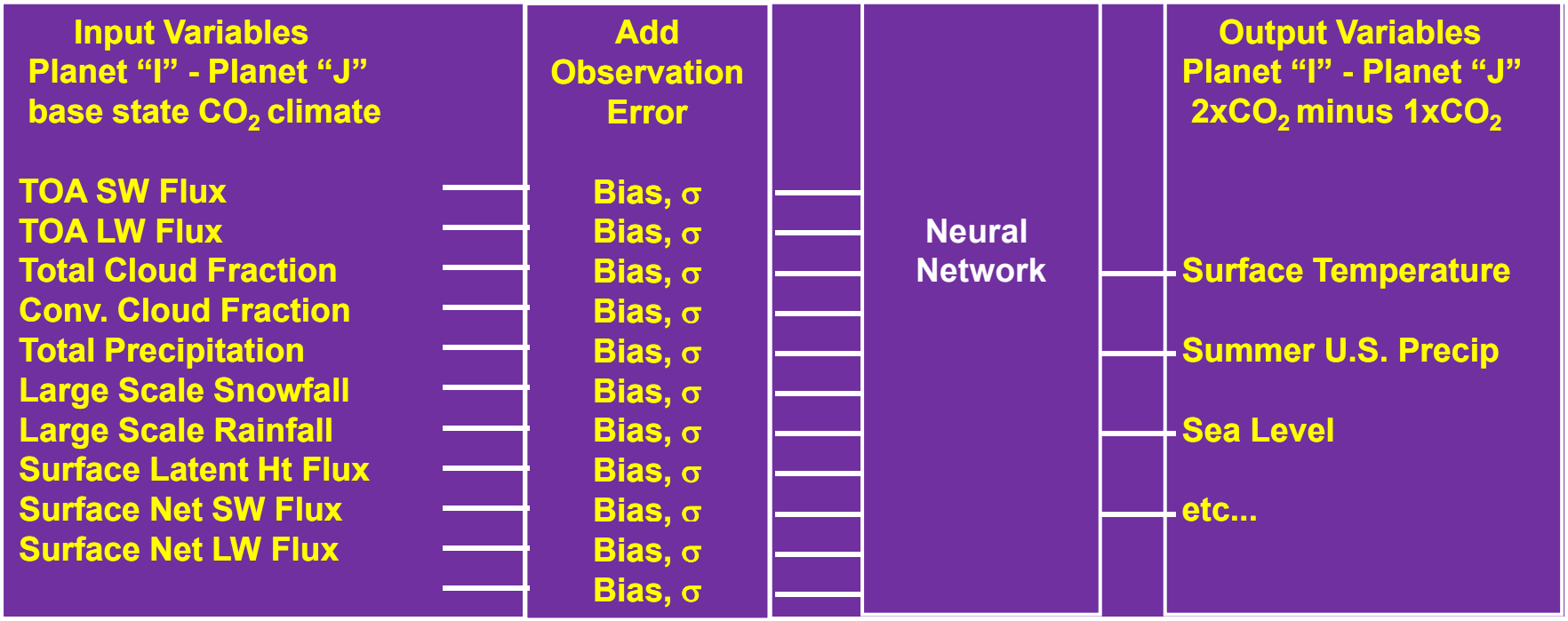
Linking observation uncertainty and uncertainty in climate sensitivity



Uncertainty in climate sensitivity

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f (uncertainties in parameters that are observable from satellite)

Some conclusions from earlier studies

1. **if the uncertainties of all the global mean observables are near zero, the uncertainty of climate sensitivity reduce from 1.5 ^{0}C to 0.7 ^{0}C**

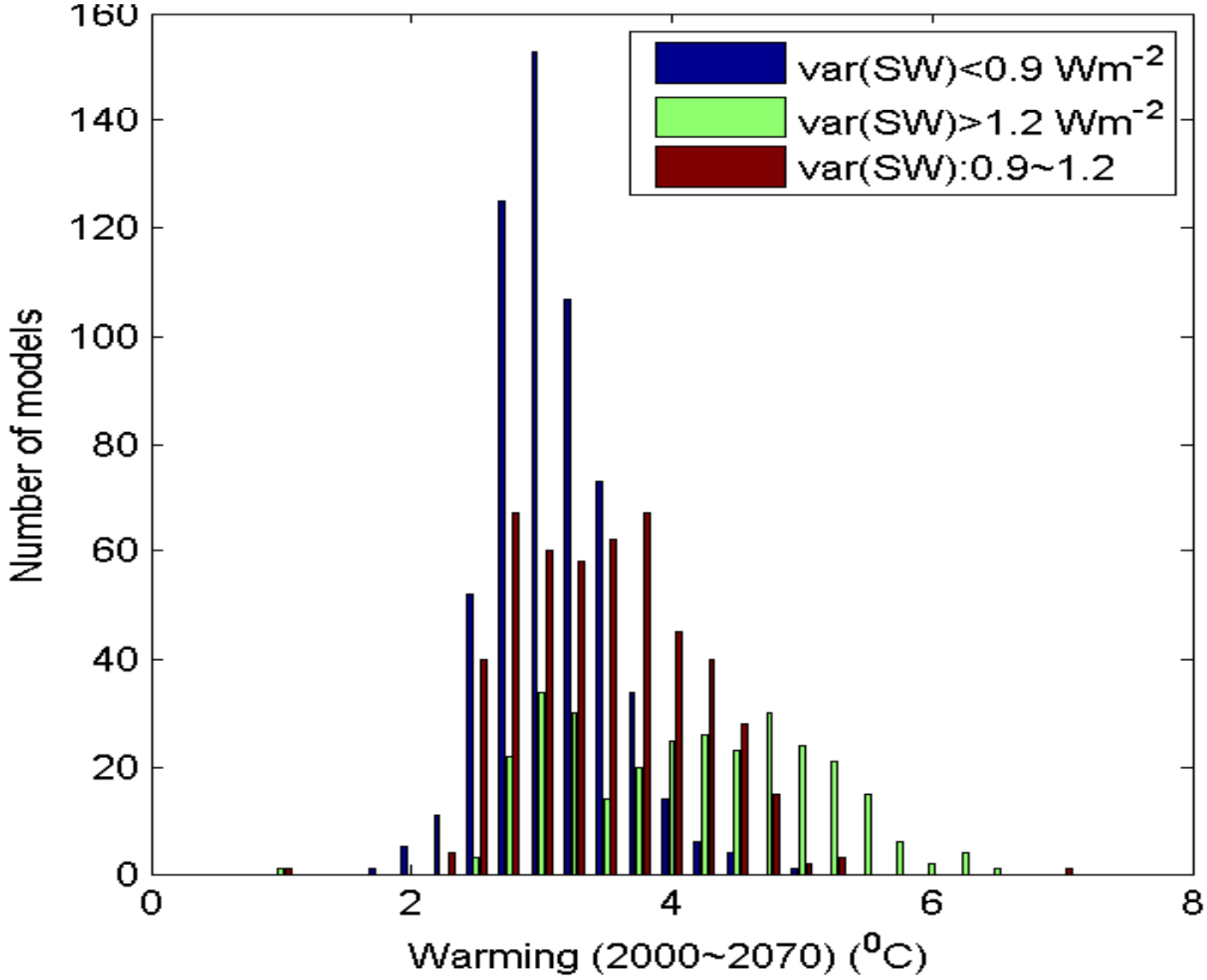
2. **If the uncertainties of decadal trends of a few key parameters are less than 15%, the uncertainty of climate sensitivity reduce from 1.5 ^{0}C to around 0.1 ^{0}C**

Problem

Accurate decadal trends can be very difficult to get

Recent studies are focused on exploring possibility of linking uncertainties of seasonal variations, regional statistics to climate sensitivity uncertainty

Can we use shorter time scale variability and historical data to improve the climate prediction?



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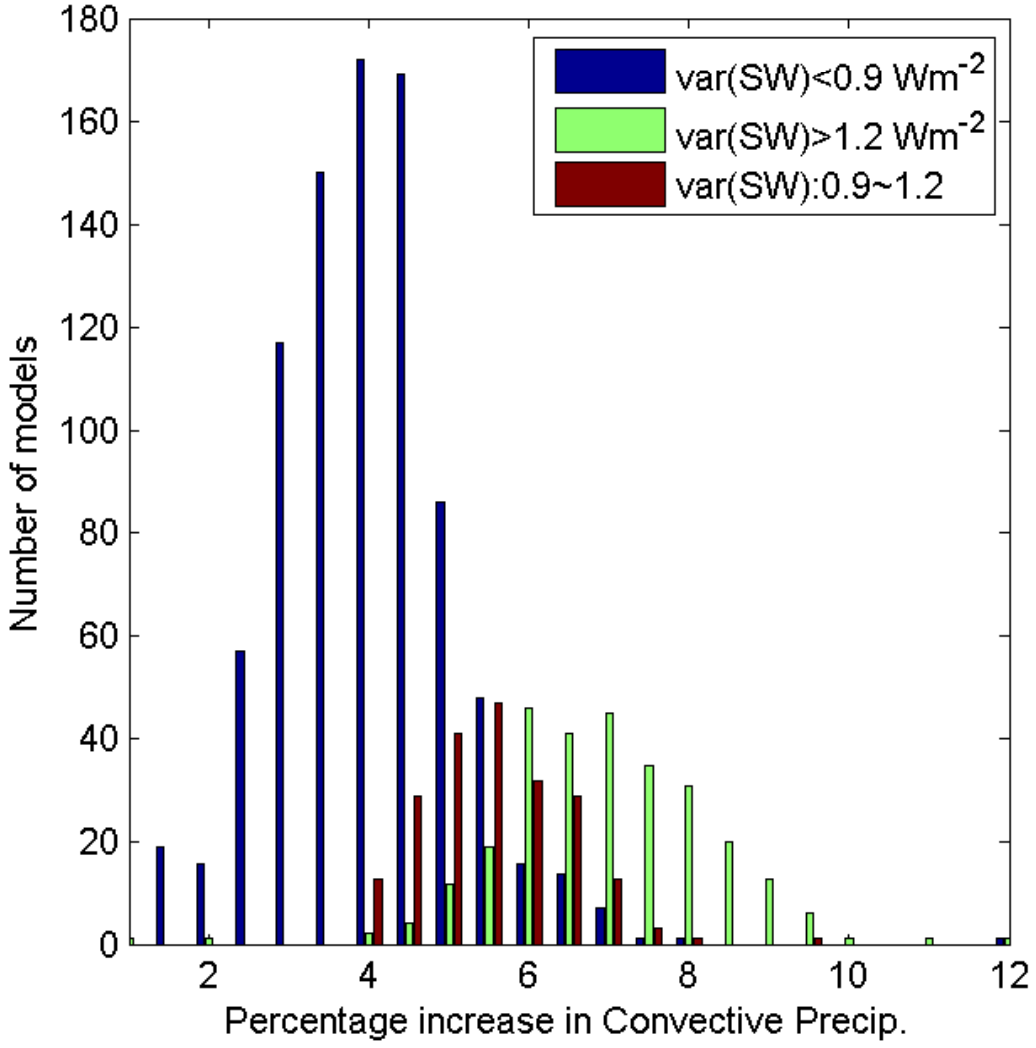

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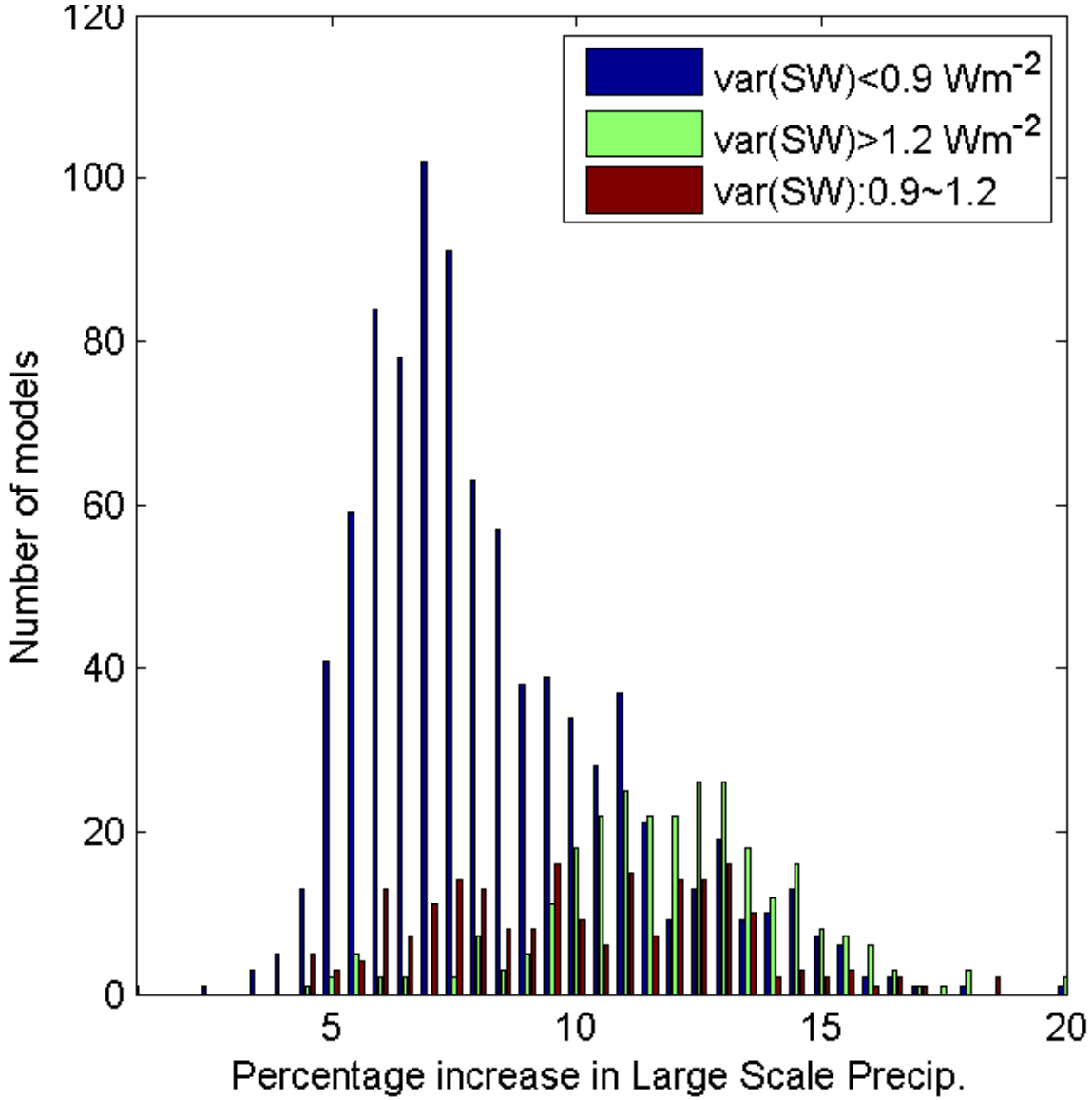

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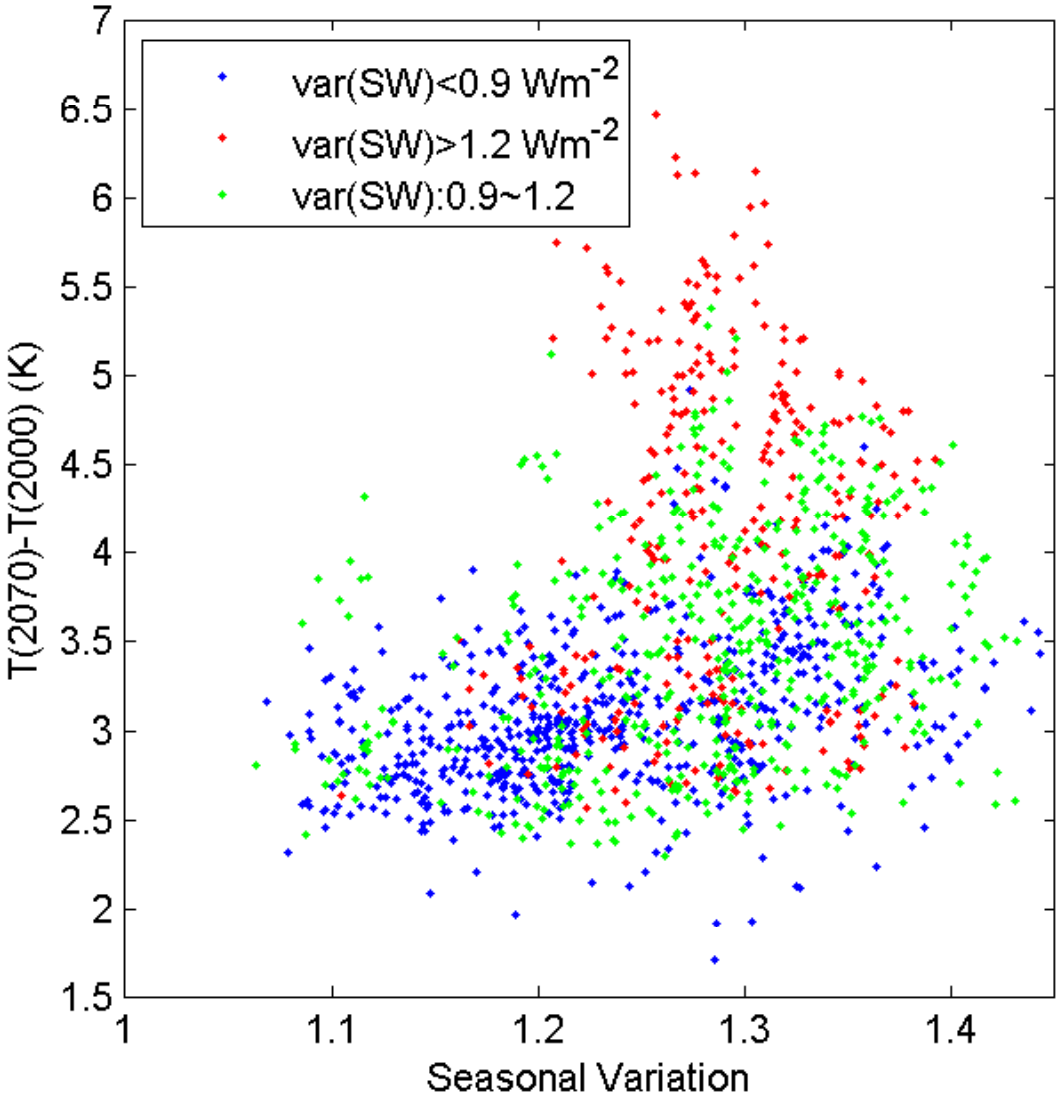

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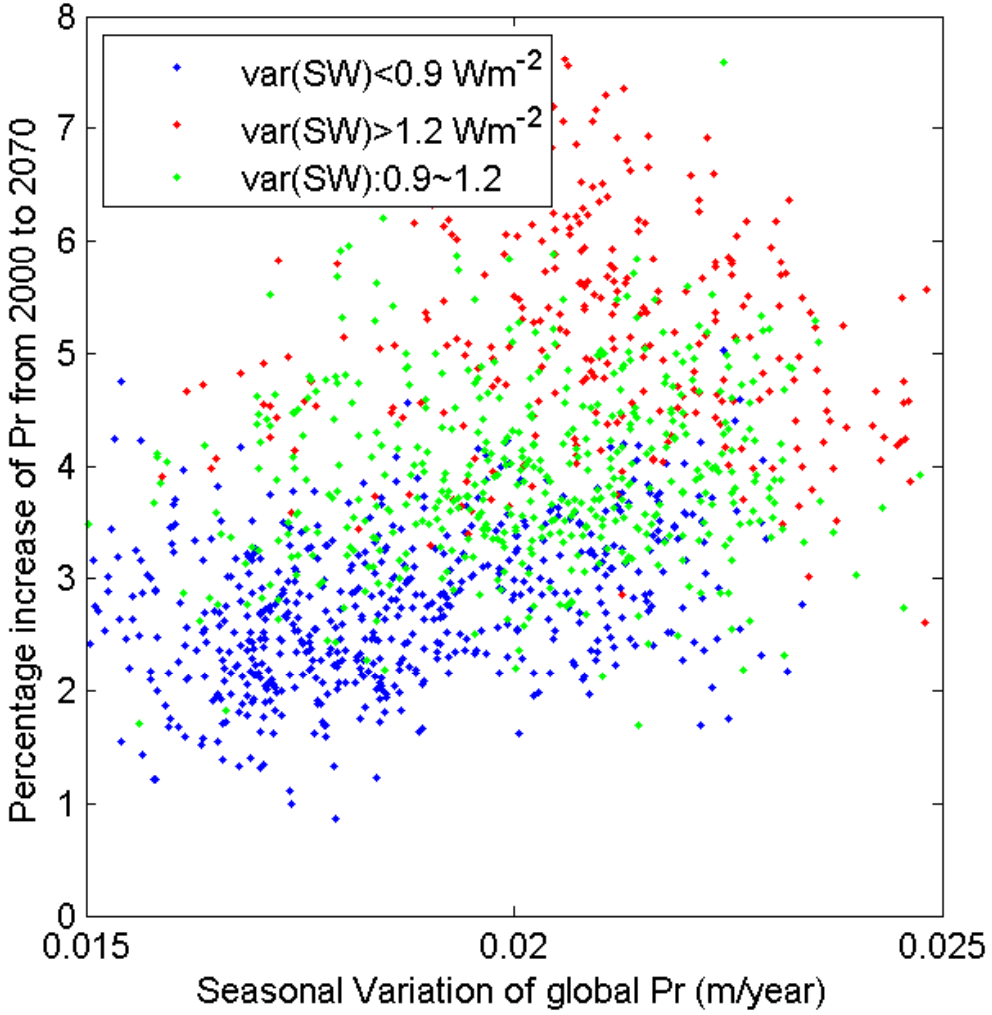
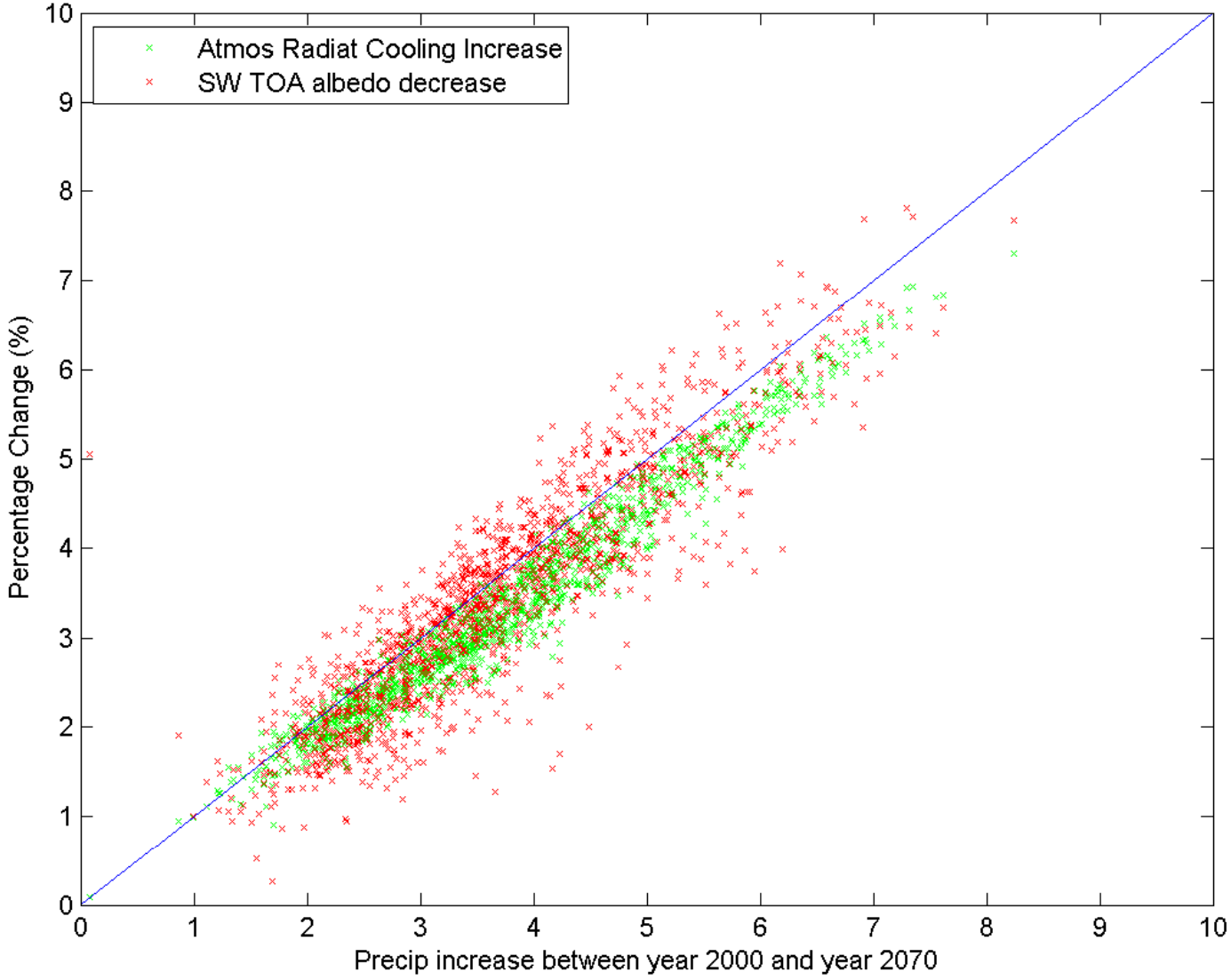


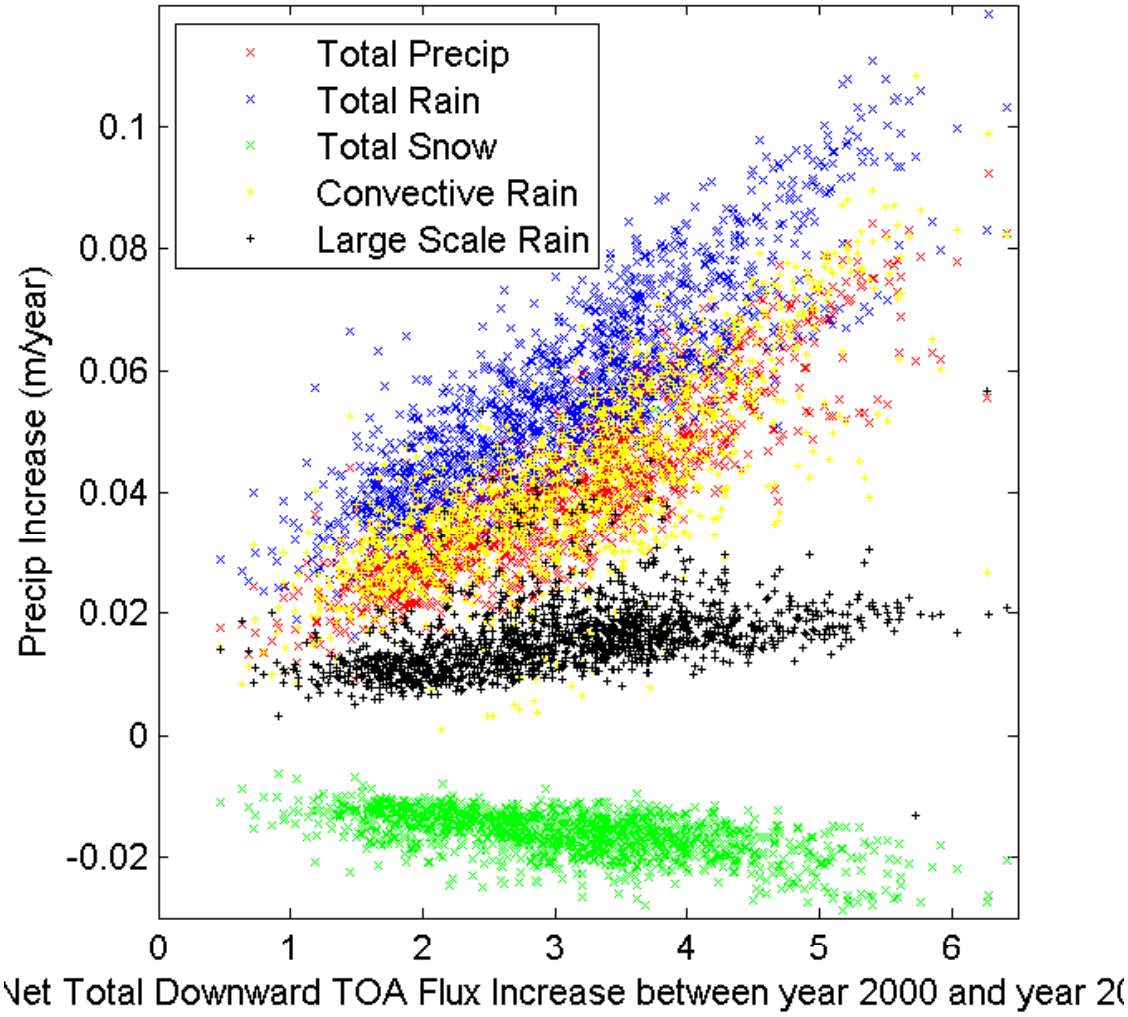
Can we use shorter time scale variability and historical data to improve the prediction?

Are the climate in the linear part (where we can link seasonal variation to climate sensitivity) or in the nonlinear part (where inter-annual, decadal scale feedbacks dominate climate sensitivity) of the plots ?

The link between changes in TOA shortwave albedo and water cycle



The link between climate sensitivity and water cycle



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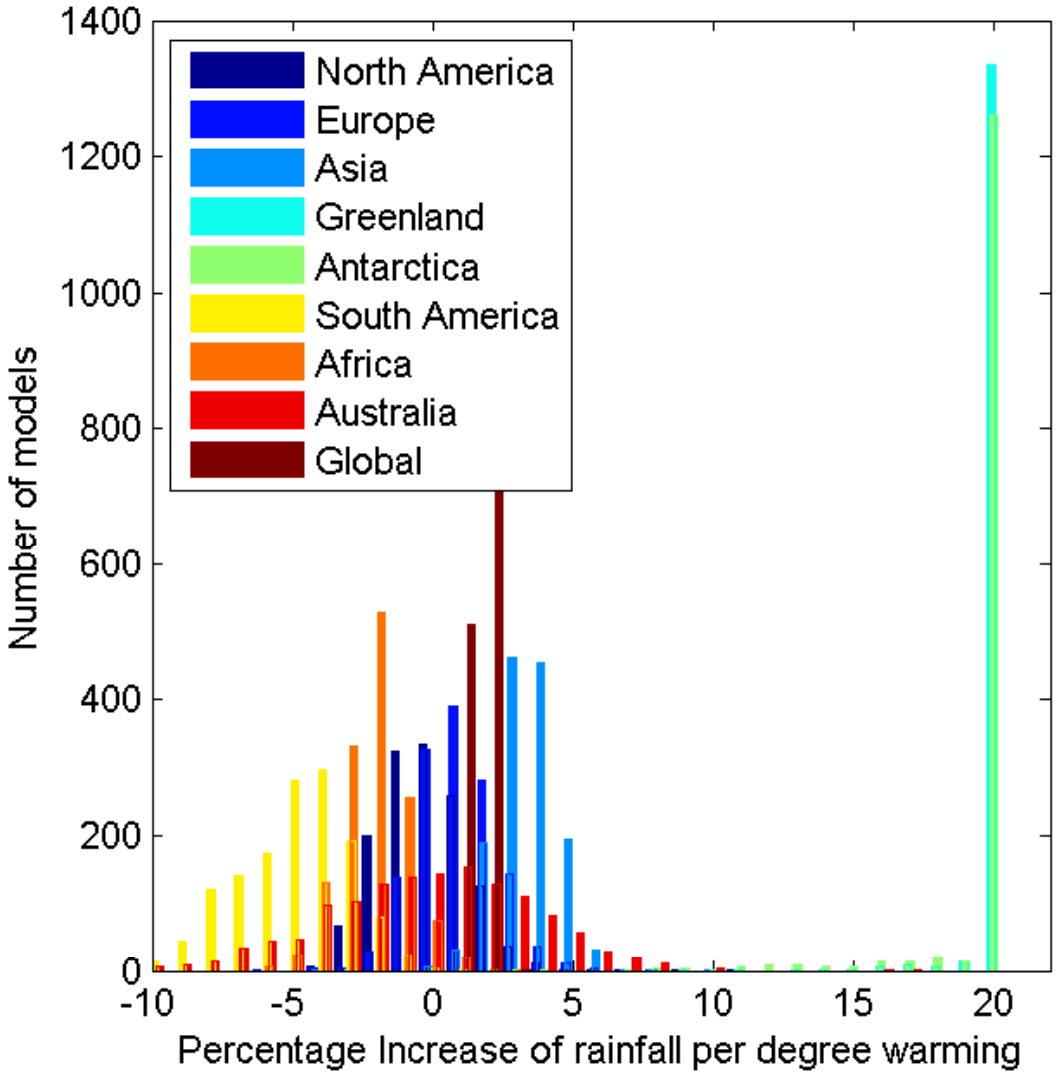

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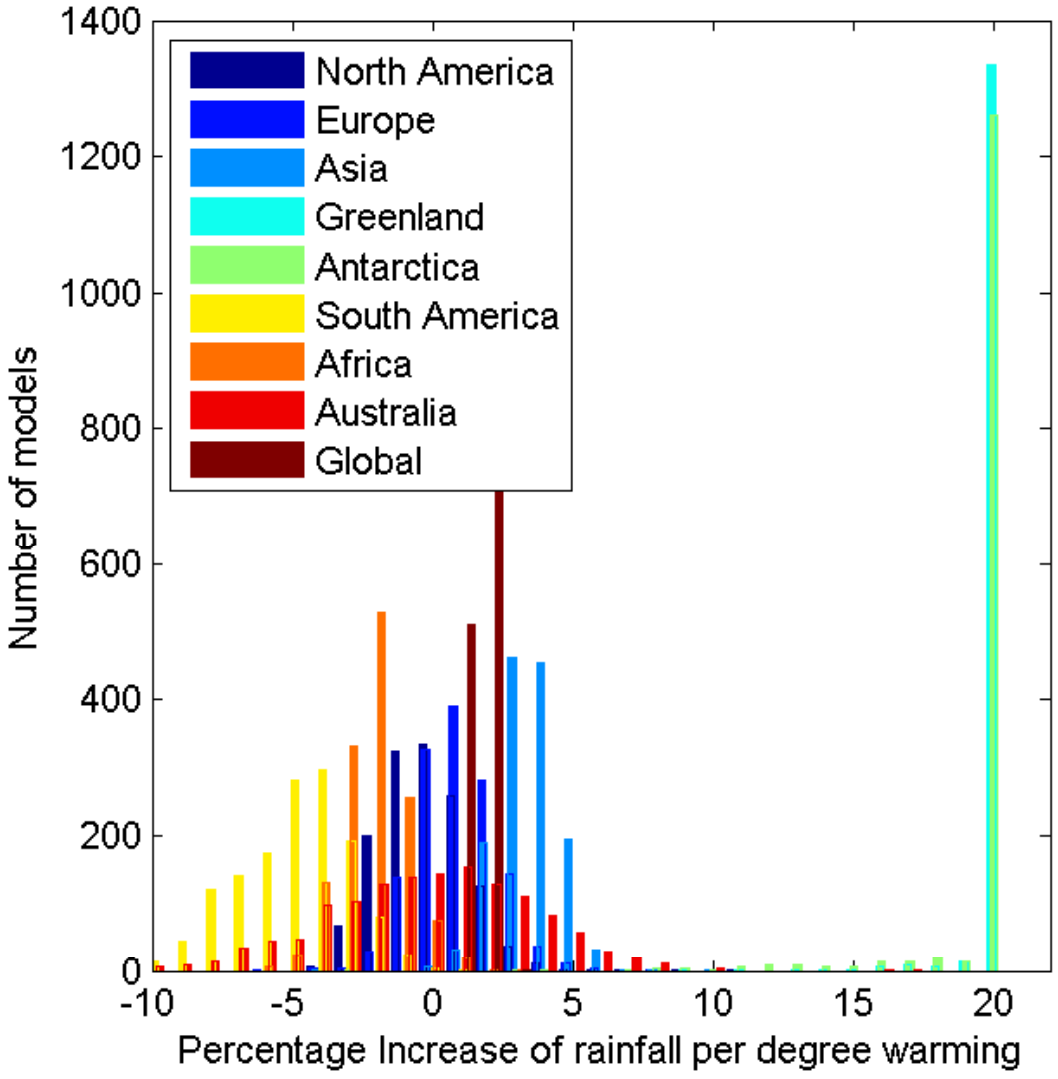

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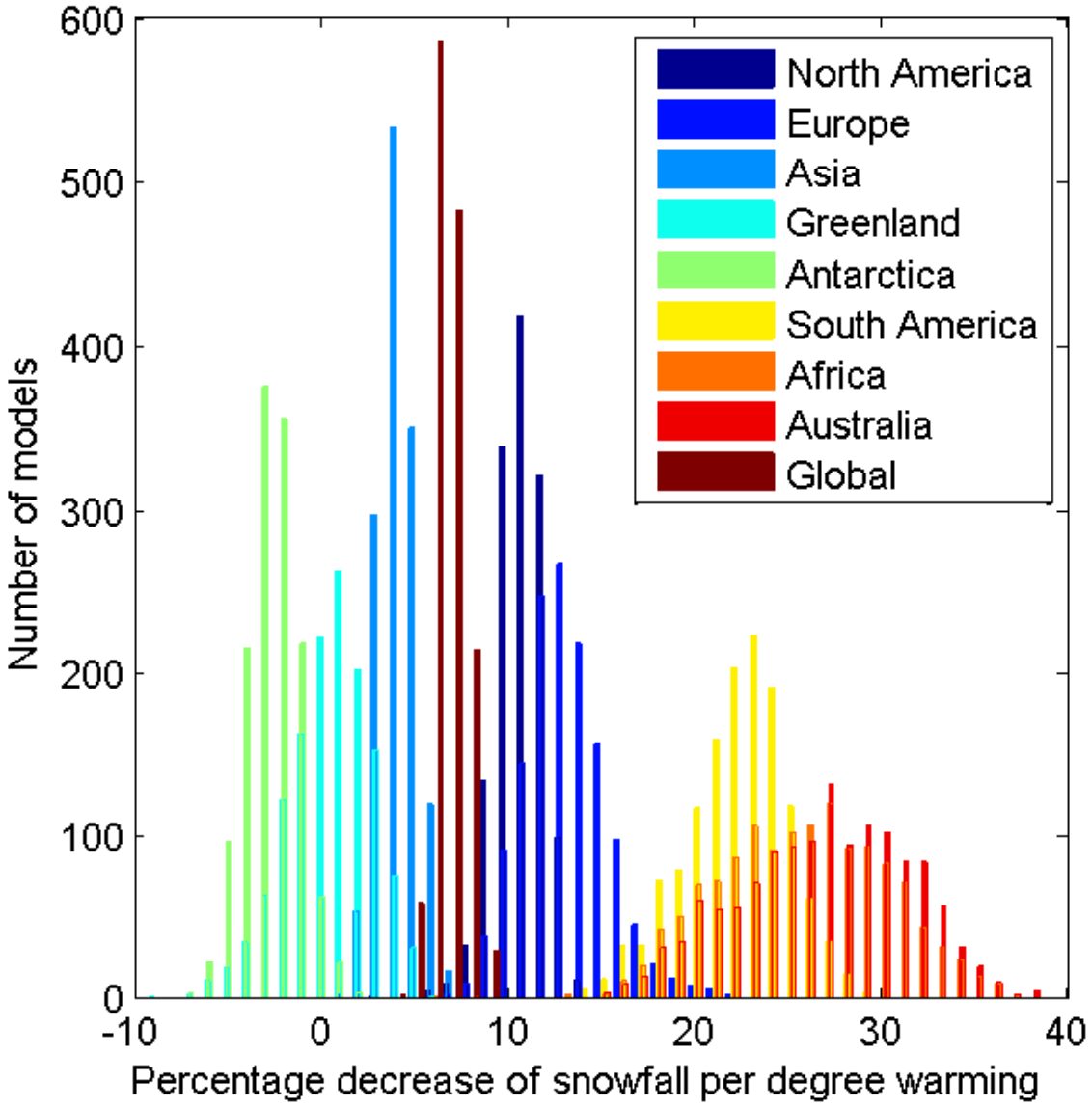
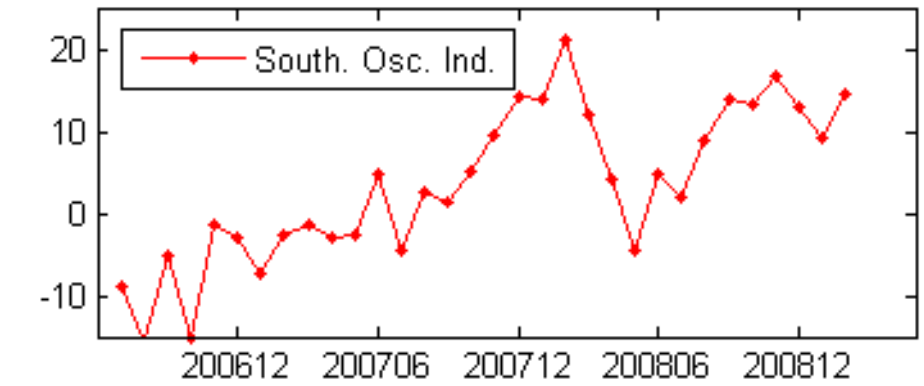


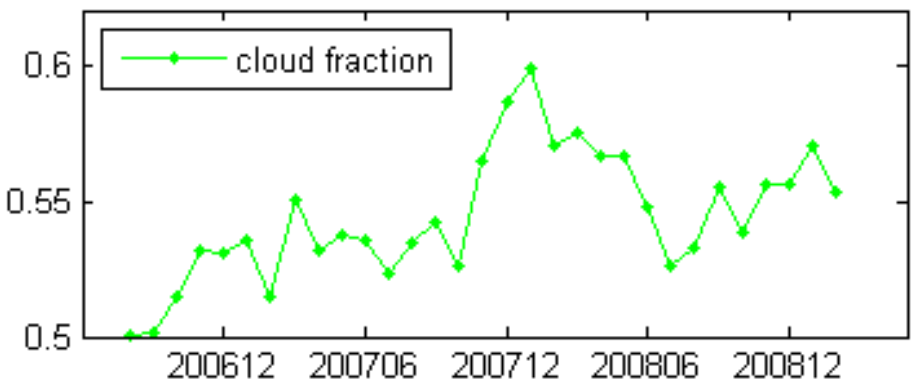
Ongoing activity

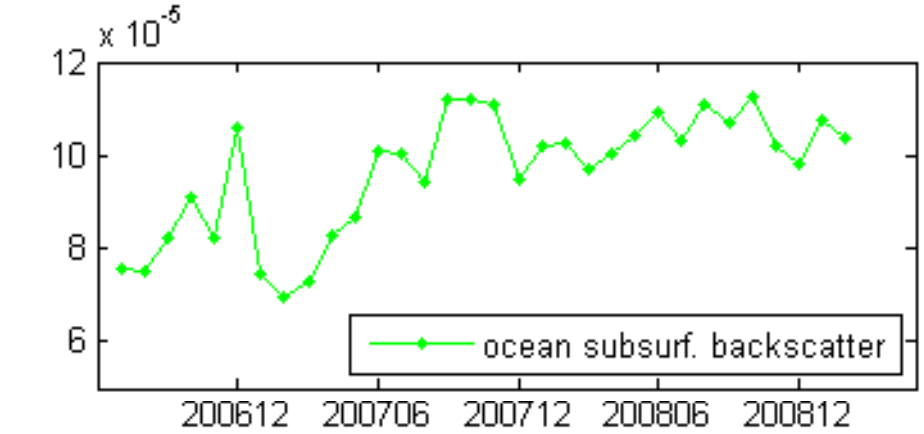
1. Studies to link climate sensitivity uncertainty to satellite measurements that are available and can be made (need advice from the group)

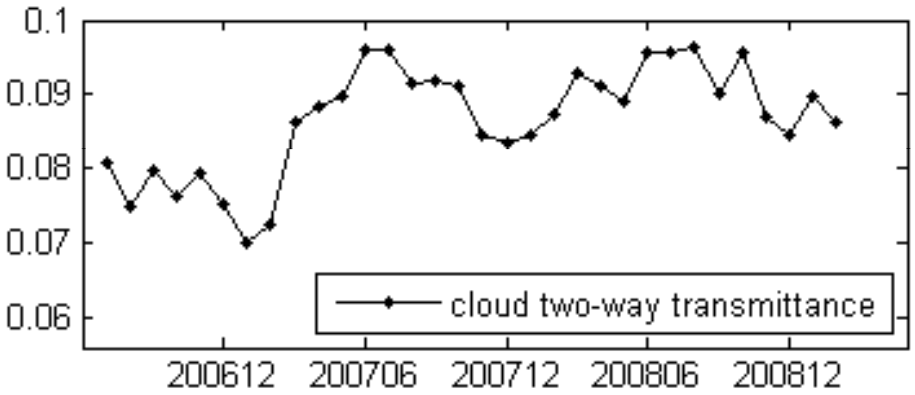
2. Quantifying the improvement of climate sensitivity estimates from ESO satellites by using A-train data for estimate current observation uncertainties and map that into climate sensitivity uncertainty

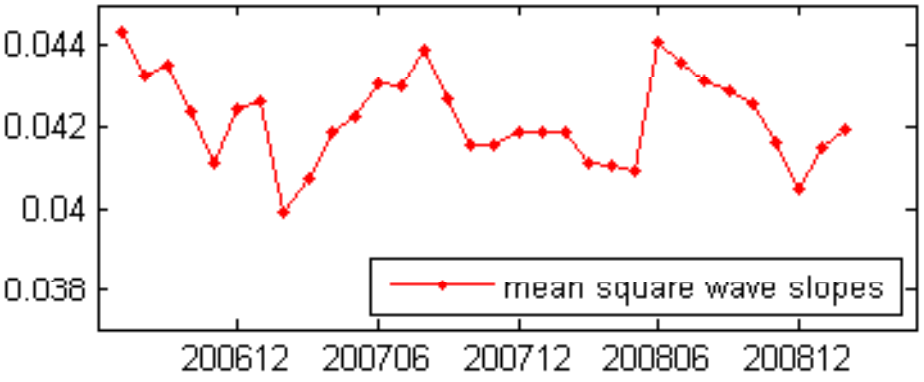
3. Assisting future active remote sensing missions: sampling studies – Are accurate measurements at nadir track enough for time series analysis (e.g., CALIPSO/CloudSat cloud properties, CALIPSO ocean surface wind at 70 footprint, …)?

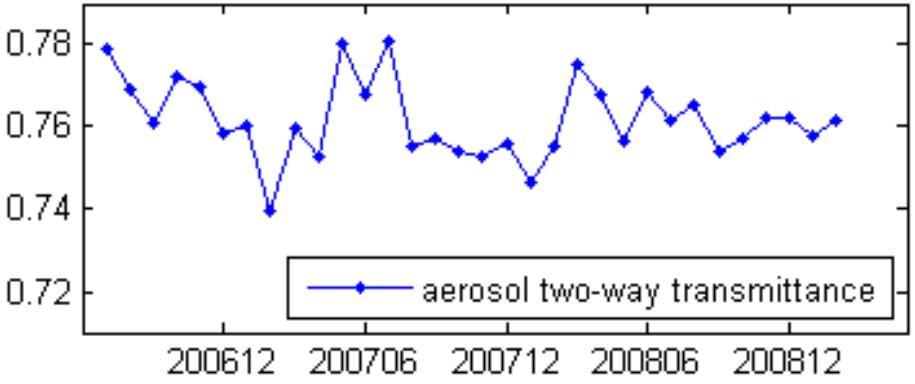






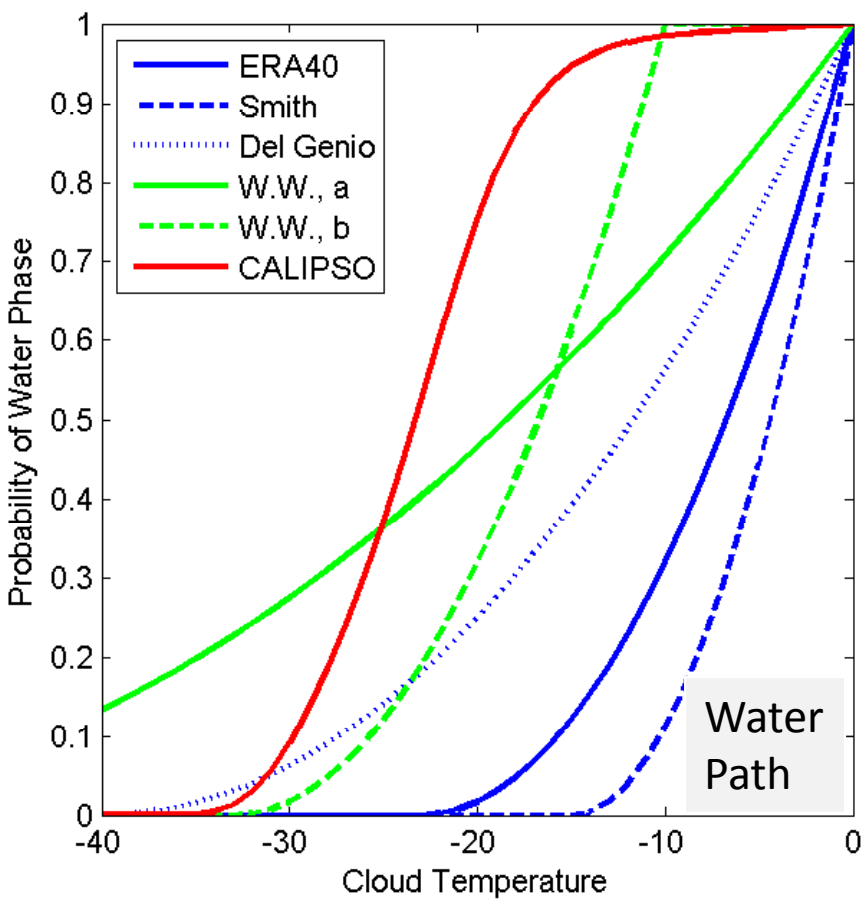


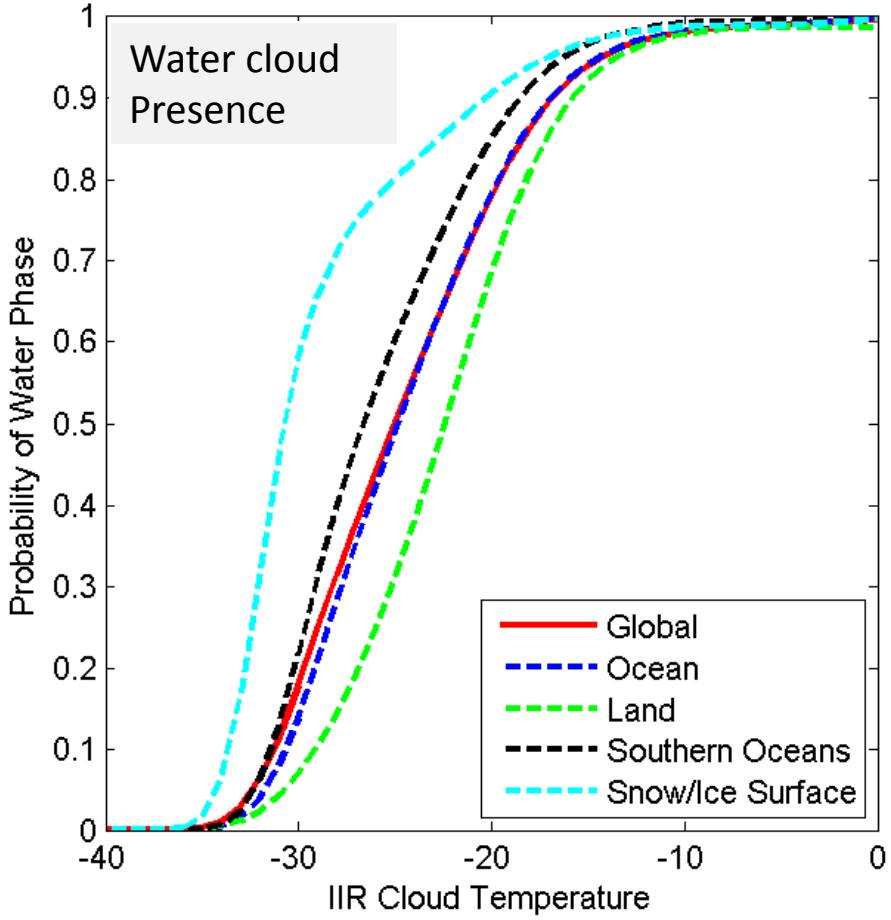


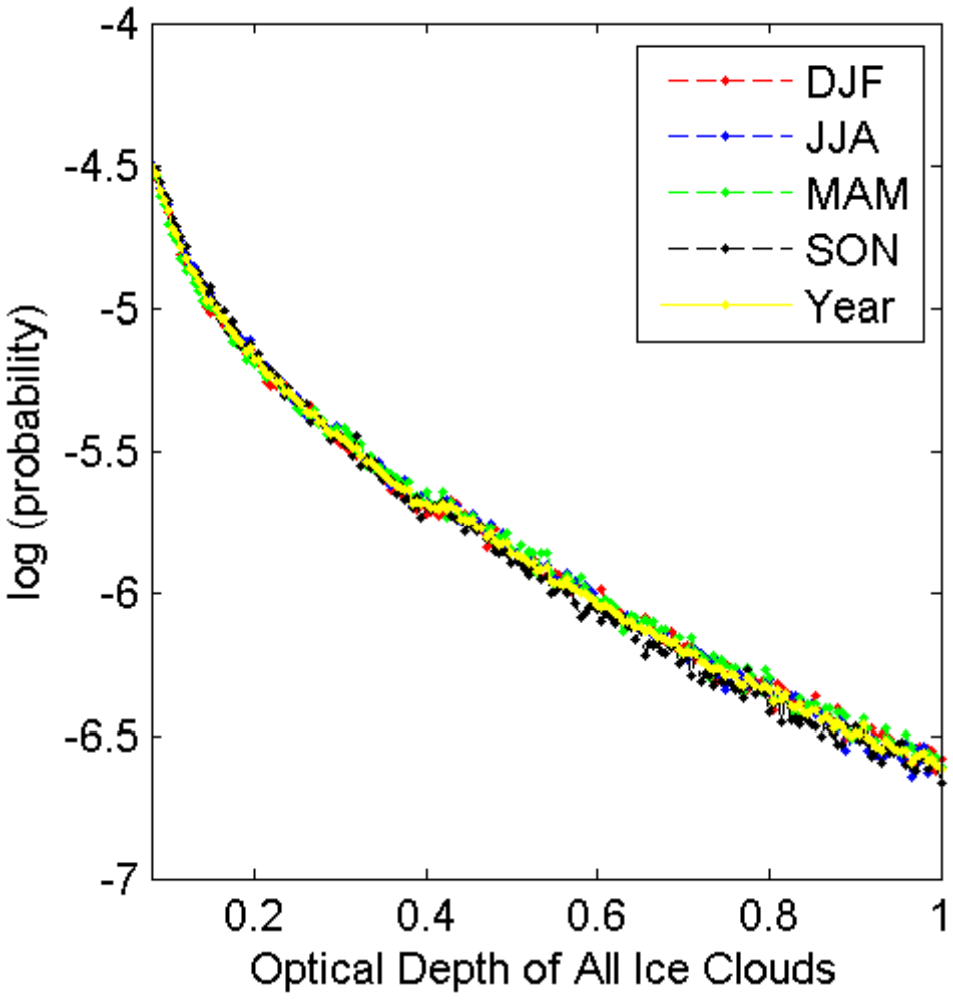


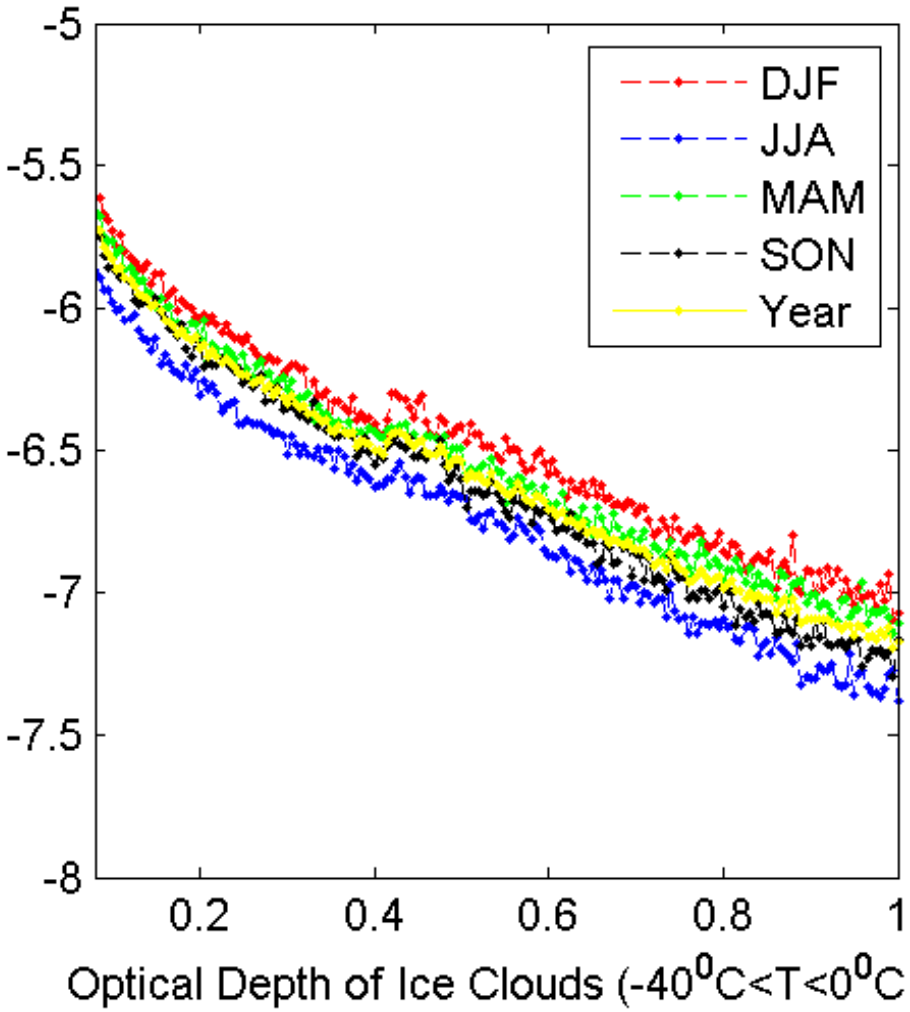
Time series: are there enough samples from nadir track ??? (here the data are from calipso)

Temperature Dependence of Cloud Liquid / Ice Water Path

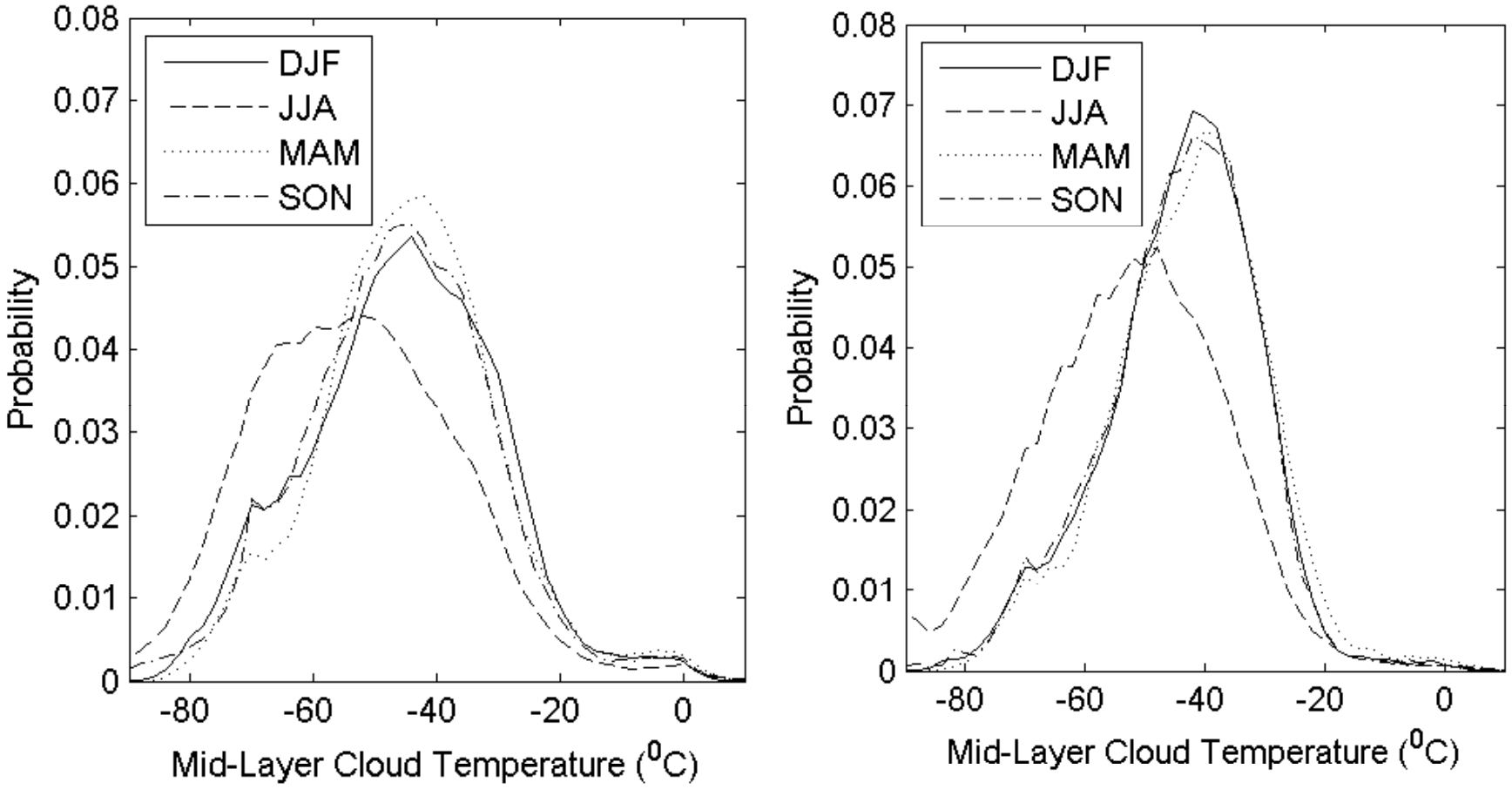








Probability distribution of cloud optical depth for thin ice clouds from CALIPSO



Seasonal dependence of cloud temperature for non-opaque ice clouds (left panel) and opaque ice clouds (right panel) from CALIPSO.